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March 1964

CENTRAL INTELLIGENCE AGENCY  
PHOTOGRAPHIC INTELLIGENCE REPORT

# MOA BAY NICKEL COMPLEX, CUBA

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### SUMMARY

A nickel-cobalt industrial complex located near Moa, Cuba, is essentially a commercial industry. The complex is divided into three sections: a mining area, a nickel and cobalt plant, and a port facility capable of serving oceangoing vessels. The material which is shipped from this complex is not a finished product, however, but is a nickel-cobalt sulphide in slurry form. The complex was originally owned by an American

firm, and the slurry was shipped by tanker to Louisiana where the sulphide was converted to metals in powder and briquette form for sale to industrial consumers. Collateral reports and ground photographs are available from the period of American ownership, and many aerial photographic missions have covered the site since the change in Cuban government.

### INTRODUCTION

The Moa Bay Nickel Complex, one of two nickel processing facilities in Cuba, is located along the northeastern coast in Provincia de Oriente near the town of Moa (20-38N 74-56W), about 45 nautical miles (nm) northeast of the US Guantanamo Naval Base (Figure 1). The Moa complex covers an area of approximately 18 square miles and includes a mining area, a nickel and cobalt plant ( ), and a port facility ( ) which serves oceangoing vessels (Figure 2). The product is not in finished form but is a slurry. The other Cuban nickel processing plant is along the same coast near Nicaro (20-42N 75-33W).

Prior to the change in Cuban government the Moa complex had been owned by the Freeport Nickel Company, a subsidiary of Freeport Sulphur Company of New York. For reasons of cost, it was feasible for the firm to divide the processing of the Moa ores between two sites. For economy in transport, the nickel-bearing Moa ores should be partially refined and concentrated before shipment; preparation of the final metal, however, requires large volumes of ammonia and hydrogen, and a good source of inexpensive natural gas is needed to synthesize both process hydrogen and hydrogen for ammonia. Therefore, the ore was treated and a concentrate for ship-

ment produced at the Moa complex; a refinery especially designed to treat the Moa slurry was constructed at Port Nickel, Louisiana (where natural gas is available), and this plant produced nickel and cobalt metals.

During the period of American ownership, the slurry was shipped in special tankers to Port Nickel. Aerial photography indicates that since the Cuban revolution the slurry has been transported from Cuba in barrels aboard conventional freighters.

Creation of harbor facilities to accommodate oceangoing vessels in the vicinity of Moa

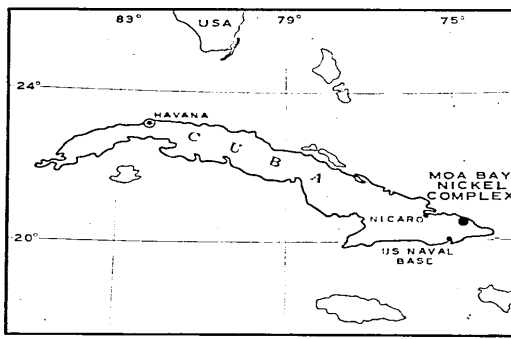


FIGURE 1. LOCATION OF MOA BAY NICKEL COMPLEX, CUBA.

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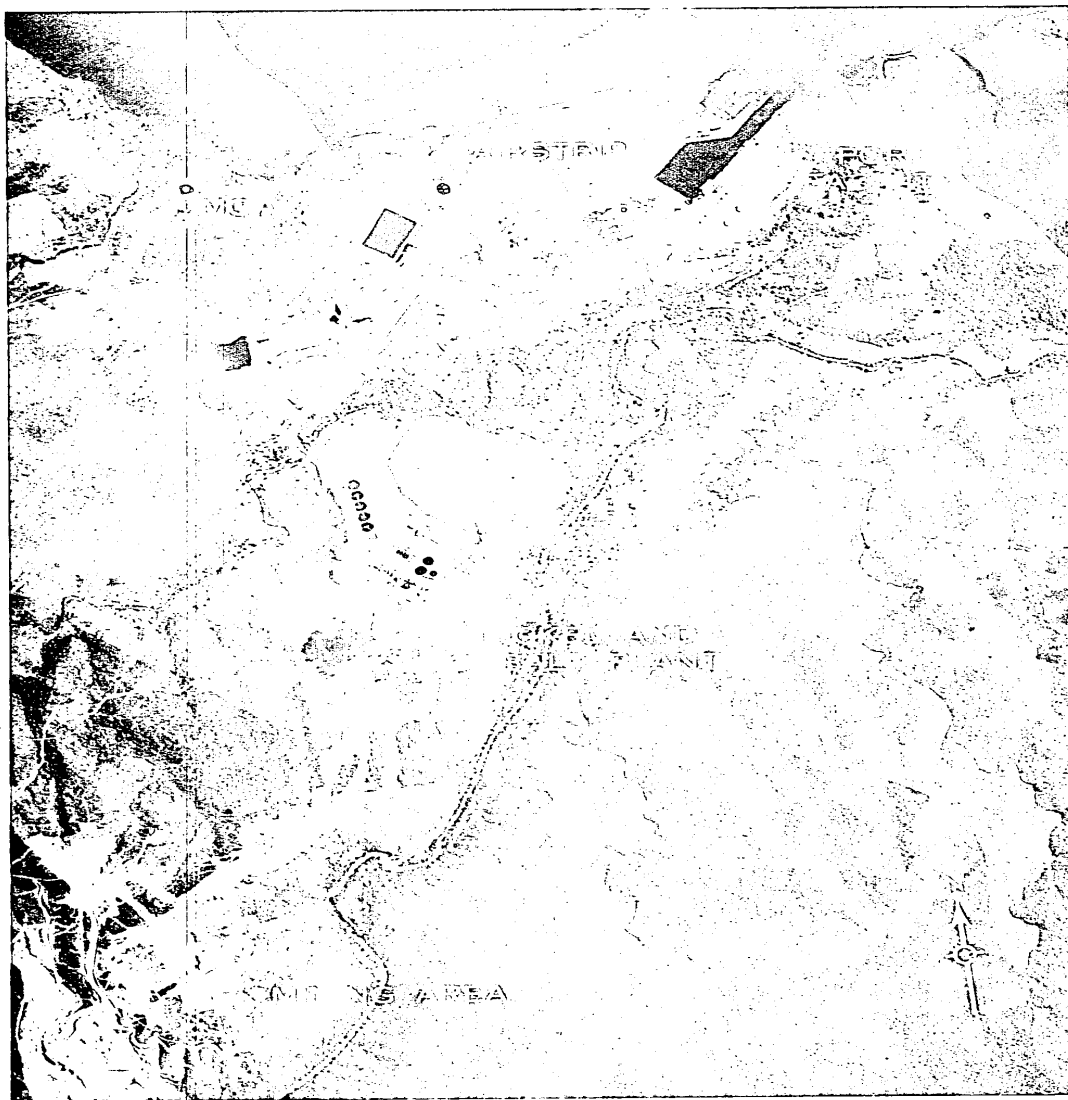


FIGURE 2. MOA BAY NICKEL COMPLEX, CUBA, [REDACTED]

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- 2 -

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included dredging both a channel and a turning basin; the difference in water depth can be observed on aerial photography of the site (Figure 2). These port facilities can serve vessels of up to 10,000 tons.

Although there is no rail service at the site, each section of the complex is road served, and there is road service between the three areas and from the complex to other nearby towns. An airstrip is also visible west of the harbor area. The slurry is transported from the mining area to the concentrating plant by a gravity-flow pipeline; the American owners used cement-type trucks to carry the concentrate from the plant to the harbor storage tanks.

Because the complex was constructed by an American firm, and it included some techniques new at the time of construction in the late 1950s, useful articles on the processes, products, and design of the facilities are available in American trade magazines of 1959 and 1960. 1/ 2/ 3/ 4/

Ground photographs made by an employee shortly before the change in Cuban government have been valuable in identifying structures and describing the relationships between various facilities; a number of these photographs are used to illustrate this report. The entire installation has been observed frequently on aerial photography since the nationalization of Cuban industry by the Castro government.

In describing the structures and processes at the complex, this report considers each of the three major sections of the facility in the chronological order of the procedures involved. Annotated line drawings present the dimensions and identify the functions of the principal structures, and flow charts depict the major steps involved in refining and concentrating the raw ore into slurry for shipment. The procedures described are those followed during the period of American ownership.

#### MINING AREA

The ores processed at the Moa complex are located in a series of gentle terraces which extend inland about 4 nm from the coast. Favorable topography with adequate subsurface drainage has been largely responsible for the development of the high-grade Moa ores; these nickel-bearing iron deposits occur as a surface mantle of reddish-brown soil varying in thickness from 10 to 100 feet. The open-pit method is used in mining these ores; a layout of the mining area can be seen on Figure 3, and Figure 4 presents a ground view of this section of the complex.

The nickel-bearing ores at Moa average about 1.35 percent nickel, 0.13 percent cobalt, and 46.5 percent iron; the Moa deposits differ significantly from those at the other major Cuban nickel facility, Nicaro, about 45 nm to the west.

The small amount of magnesium in the Moa Bay ores makes it feasible to use acid-leaching techniques which cannot be applied to the high-magnesium Nicaro ores. The Moa deposits contain about twice as much cobalt as those at Nicaro and include little silicate-type serpentine ore.

A separation of ore materials by 20-mesh screening (20 openings to the linear inch) is sufficient to prepare suitable processing plant feed from the high-grade Moa deposits. The steps in the slurry preparation system can be followed on a flow chart (Figure 5). In preparation for the acid-leaching process the ore is combined with water to form a slurry and wet screened at 20-mesh. An apron feeder and inclined belt conveyor (Figure 6) feed ore from trucks or storage

- 3 -

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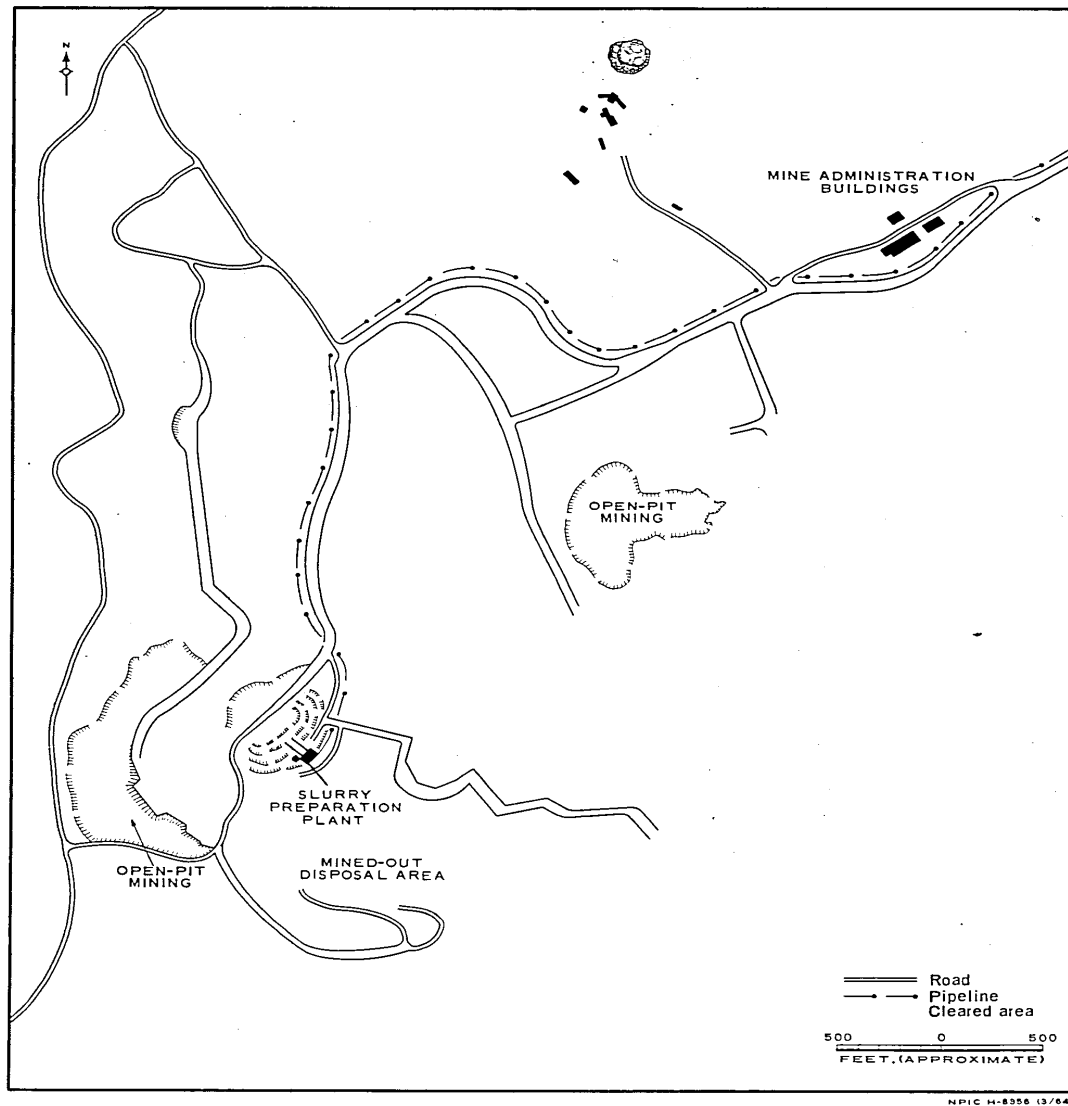


FIGURE 3. MINING AREA, MOA BAY NICKEL COMPLEX.

- 4 -

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FIGURE 4. GENERAL VIEW OF MINING AREA FROM THE NORTH, MAY 1960.

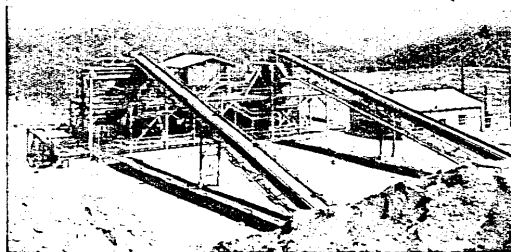


FIGURE 6. CONVEYERS AND SLURRY PREPARATION PLANT VIEWED FROM THE LOADING PLATFORM, MAY 1960.

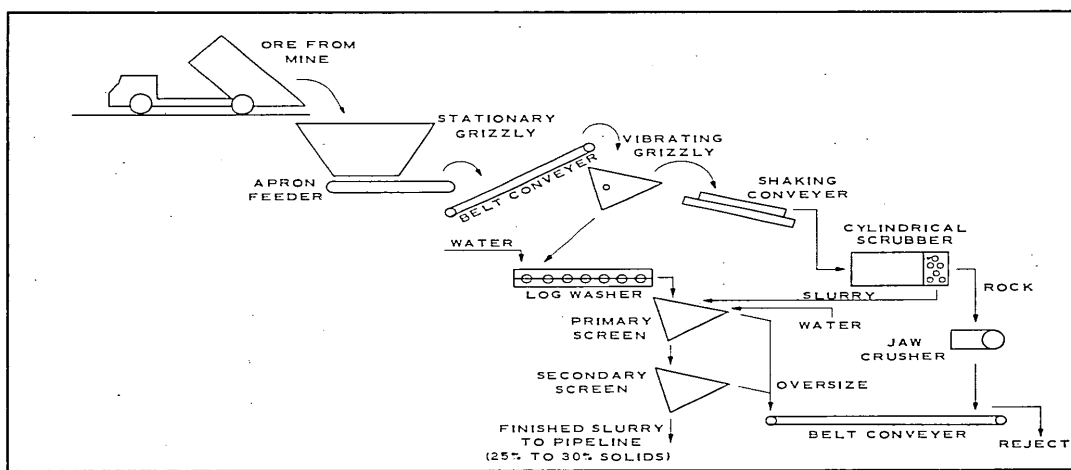


FIGURE 5. SLURRY PREPARATION SYSTEM.

piles into the slurry preparation plant where a coarse vibrating screen or grizzly removes large stray rocks. The finer material goes directly to mechanical trough (log) washers, and the slurry from the washers at a concentration of about 25 percent solids passes through two more screening stages. The oversize rock from

the initial screening is scrubbed free of any remaining ore in a cylindrical scrubber and then passes through a jaw crusher; the crushed rock is combined with rejected material from the two slurry screenings and carried by belt conveyers to a mined-out disposal area adjacent to the slurry plant.

- 5 -

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## NICKEL AND COBALT PLANT

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A layout of the facilities in and around the main nickel and cobalt plant can be found on Figure 7. The screened raw ore slurry moves from the mining area through a gravity-flow pipeline approximately 14,000 feet long to the main plant (Figure 8) and enters an elevated splitter box from which it can be fed through pipes to either or both of two storage thickeners, each [REDACTED] in outside diameter (item 1, Figure 7). The slurry enters the thickeners at a density of 25 percent solids and is settled to over 45 percent solids to provide feed for the leaching process. The overflow water is recirculated to the slurry preparation plant by two-stage centrifugal pumps.

A critical stage in the Moa Bay process is the selective leaching of nickel and cobalt from the predominant gangue fraction (the nonvaluable minerals in the raw ore). The ore slurry which enters the leaching plant (Figure 9 and item 5, Figure 7) is entirely mixed oxides; there are no sulphates, sulphides, or carbonates.

The leaching system is split into four identical reaction trains, each with four vessels arranged in series (Figure 10). The vessels in which the leaching reaction takes place measure 10 feet in diameter and are 50 feet high. Raw ore slurry at the maximum density that can be prepared and handled is pumped from the storage thickeners through preheaters, where it is heated by direct absorption of steam at a pressure of 30 pounds per square inch (psi), and into mechanically agitated storage tanks; each reaction train has two of these tanks. Rubber-lined centrifugal booster pumps pump the slurry into a slurry heater tower above the first reaction vessel; steam at 650 psi is used to heat the slurry. Following a four-stage continuous gravity-flow pattern, the slurry passes through all four reaction vessels. Sulphuric acid at 90

percent concentration is fed into the first vessel, and high-pressure steam at 650 psi is introduced into all four vessels to induce agitation and circulation. The leach slurry overflowing the fourth vessel passes through a heat exchanger (slurry cooler), through special flow control chokes, and into a flash tank. Steam from the cooler at 30 psi and from the flash tank at atmospheric pressure is utilized elsewhere in the plant area. From the flash tank the slurry flows by gravity to the washing and neutralization systems (Figure 11).

A second important phase of the Moa Bay operation is the preparation of a high-grade concentrate from the dilute leach liquor. This phase involves: separating the liquor from the barren solids; adjusting the composition of the liquor; and treating it to precipitate the concentrate.

A six-stage washing or counter-current decantation (CCD) system (Figure 12 and item 9, Figure 7) separates the leach liquor from the barren solids which settle readily to a density of 55 to 60 percent and can be thoroughly washed with relatively little dilution of the solids. Because of the temperature of the slurry, the tanks for the first two stages are concrete and lined with acid-proof brick over asphaltic membrane; the tanks of the last four stages have concrete ring walls, protected by acid-proof brick at the solution level, and waterproof asphalt-paved bottoms. The thickener mechanisms in the system must be acid resistant. The washed barren solids from the sixth stage CCD tank are diluted with water for ease in handling and pumped to an impounding basin.

The raw liquor from the first stage CCD tank is pumped to the neutralization system (Figure 13 and items 6, 7, and 8, Figure 7) where it is pretreated with impure hydrogen

- 6 -

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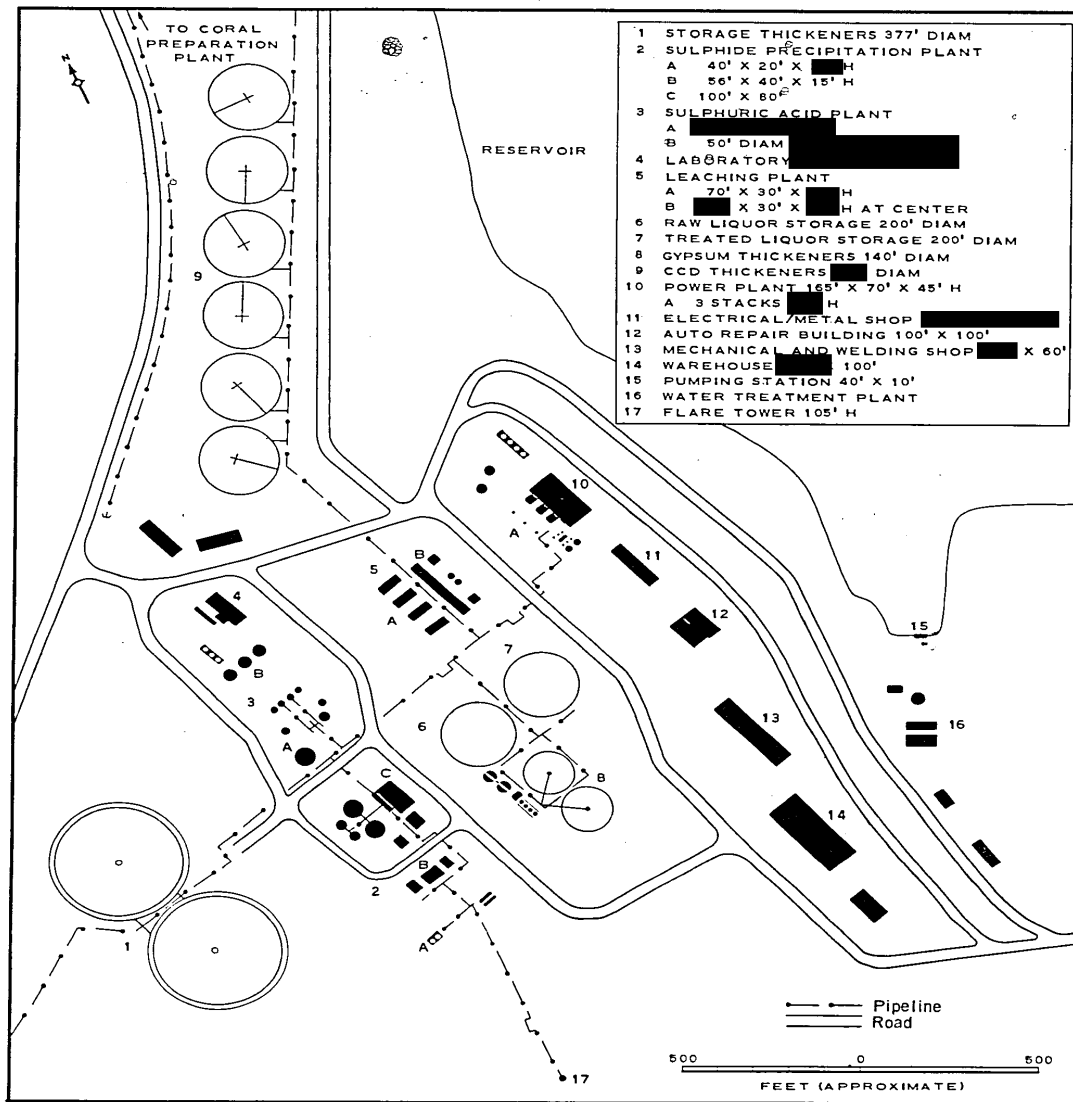


FIGURE 7. NICKEL AND COBALT PLANT, MOA BAY NICKEL COMPLEX.

- 7 -

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FIGURE 8. PARTIAL VIEW OF NICKEL AND COBALT PLANT AREA FROM THE NORTH, MAY 1960.

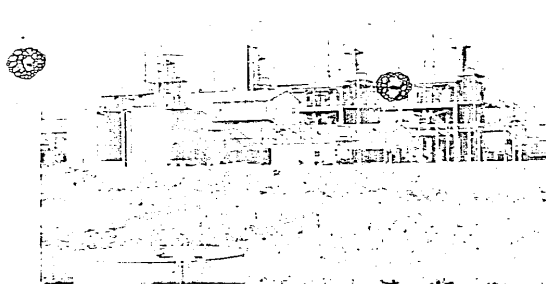


FIGURE 9. GENERAL VIEW OF LEACHING PLANT FROM THE NORTHEAST, MAY 1960.

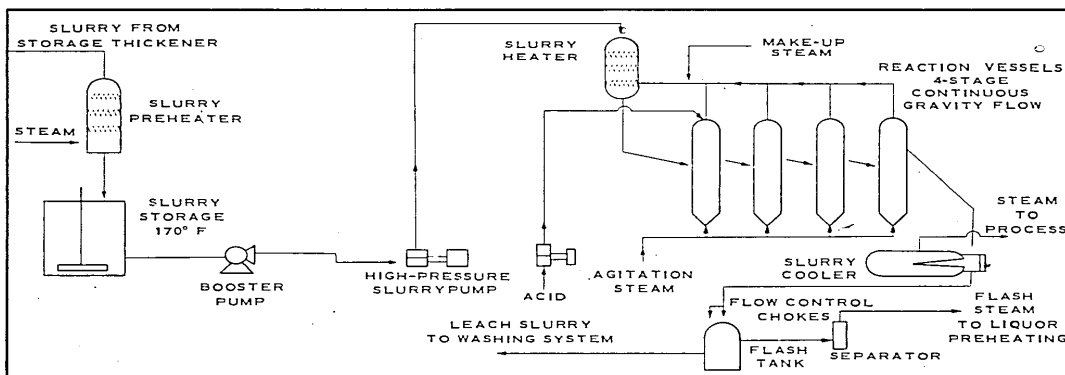


FIGURE 10. LEACHING SYSTEM.

sulphide to destroy chromate chromium and to reduce some ferric iron to a ferrous state. The liquor is next treated with coral mud to remove the free acidity.

The coral mud used in the neutralization system is prepared (Figure 11) in a plant at the port facility of the Moa Bay complex. The mud is dredged from the landward side of an offshore reef and transported by barge to the preparation plant (Figure 14) along the docks; it is slurried in fresh water, screened free of trash, and water-washed in two stages to yield a solution containing less than 500 parts per thousand of chloride. The

washing stages also thicken the coral mud which is pumped to the neutralization system through a pipeline approximately three miles long. Analysis of the washed coral indicates that it is over 90 percent calcium carbonate; its porous nature results in a rapid reaction with the free acid in the raw liquor.

Variable speed diaphragm pumps meter the coral mud into the neutralization system which is a four-stage cascade, or a series of four mechanically agitated reaction tanks (Figure 11). These wooden tanks are covered and provided with draft fans to draw off carbon dioxide gener-

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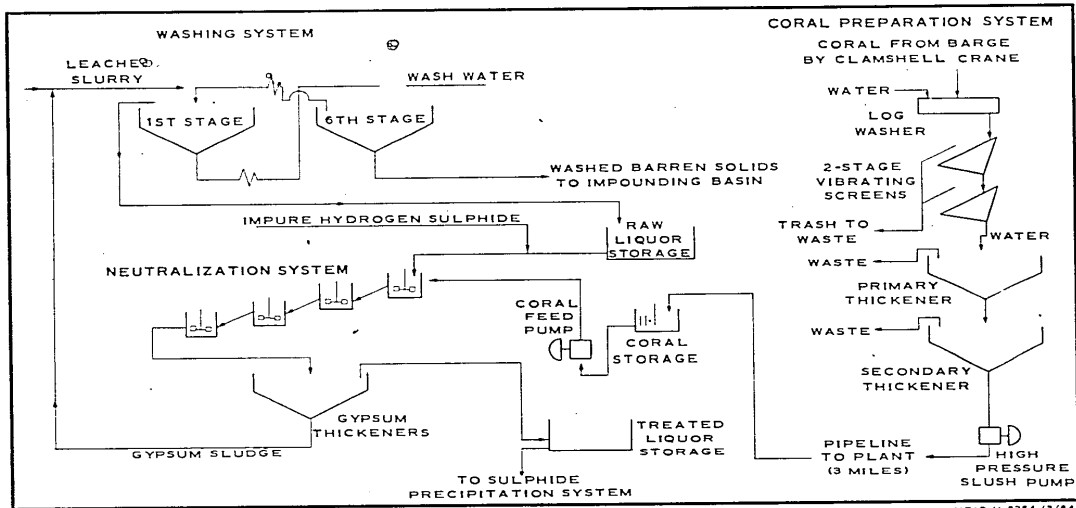


FIGURE 11. WASHING, NEUTRALIZATION, AND CORAL PREPARATION SYSTEMS.



FIGURE 12. COUNTER-CURRENT DECANTATION TANKS, WASHING SYSTEM, MAY 1960.

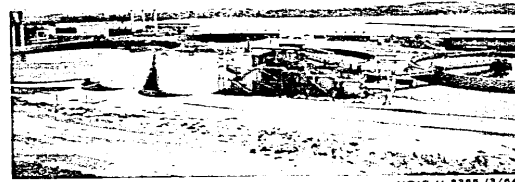


FIGURE 13. VIEW OF NEUTRALIZATION SYSTEM FROM THE SOUTHWEST, MAY 1960. Gypsum thickeners can be seen on the right.

ated by the neutralization reaction. This reaction precipitates gypsum (Figure 13) in proportion to the amount of acid destroyed; the gypsum is returned as a thickener sludge to the CCD system handling the leached slurry.

The neutralized liquor which forms the feed for the sulphide precipitation system (Figure 15 and item 2, Figure 7) is first pumped to pre-

heaters; these are located in the leaching system area to utilize atmospheric steam from the leaching flash tanks. Then the liquor is pumped to the heaters of the sulphide system proper where direct contact with steam heats the liquor further before it is pumped into precipitation autoclaves. These autoclaves are horizontal cylinders, lined with acid-proof brick and divided

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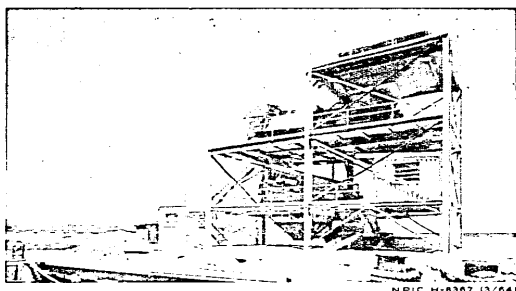


FIGURE 14. RECEIVING HOPPER, CONVEYERS, AND SCREEN TOWER, CORAL PREPARATION PLANT, MAY 1960.

internally into three compartments by brick baffle walls; each compartment is fitted with a mechanical agitator.

Gaseous, high-purity hydrogen sulphide is injected into the autoclaves, precipitating 99 percent of the nickel and 98 percent of the cobalt

from the liquor as the sulphide product. This precipitated slurry is blown directly down into flash tanks, where the excess hydrogen sulphide separates; the gas is cooled and dried by washing with water and is recycled by compression to the autoclaves. There are four complete trains (heater, autoclave, and flash tank) in the precipitation system, of which one is a spare to permit downtime for cleaning the scale generated by the process.

The flashed liquor carrying the suspended sulphide product flows by gravity to two thickeners, each 60 feet in diameter, operating in parallel. At this step the waste solids separate, and the thickened sulphide is washed in two stages by cooling water from the hydrogen sulphide cooling system. The washed sulphide, now a slurry with a density of about 65 percent solids, is transferred by truck to storage tanks in the port facility area.

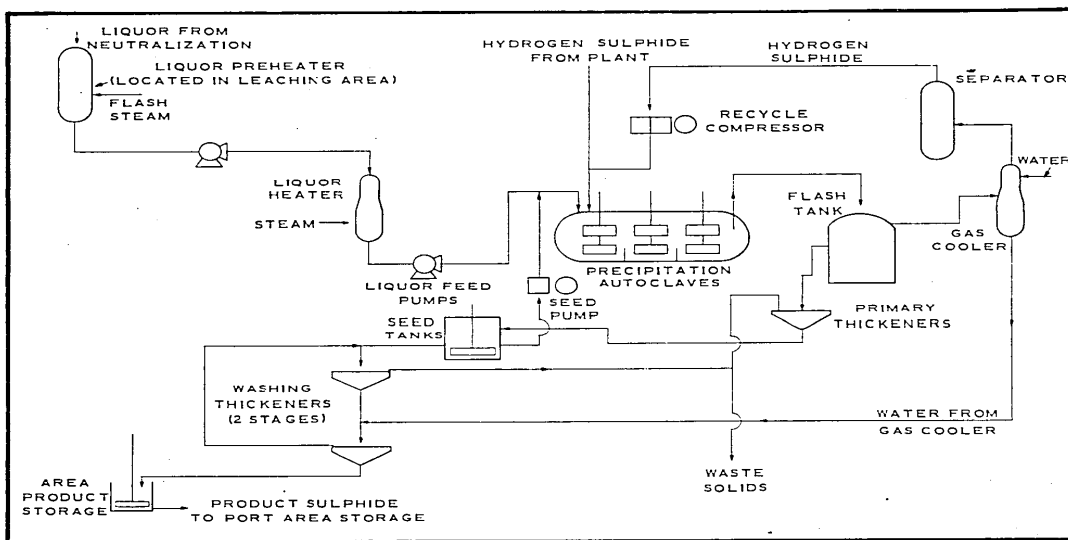


FIGURE 15. SULPHIDE PRECIPITATION SYSTEM.

- 10 -

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## PORT FACILITY

When the Moa Bay complex was built, a major port installation (Figure 16) was required in order to serve the oceangoing vessels and to handle and store the fuels, the slurry product, and the materials needed in the various processes. A channel approximately 2,100 feet long was dredged in the cove known as Bahía de Yaguasey to the port entrance, which is about 350 feet wide. The harbor itself is about 3,250 feet long, and the turning basin is approximately 950 feet wide. The dredged area is visible on aerial photography of the site (Figure 2).

A battery of 16 wooden tanks (item 1, Figure 16) for storage of the suspended sulphide product is located at the port facility along the docking facilities on the south side of the turning basin. Each of the tanks measures about 20 feet in diameter by 20 feet high. At the time of American ownership the slurry was permitted to settle in these tanks; when a transfer from shore to ship was planned, the slurry was resuspended by a specially designed agitator which could be

moved from tank to tank. A pipeline then carried the slurry into the special tankers. Aerial photography of the port facility since the change in Cuban government indicates that the slurry product has been shipped in barrels aboard conventional freighters.

In addition to the product storage tanks, other facilities are located in the area of the south side of the turning basin (Figure 17). These facilities include 8 vertical tanks of varying sizes for fuel and acid storage and 11 horizontal tanks to store liquid petroleum gas and other liquids.

On the north side of the turning basin is the preparation plant for the coal mud; the receiving hopper and screen tower (item 3, Figure 16) can be observed near the north docking facilities. West of this section of the coral preparation system are the coral thickener and the pump station (item 4, Figure 16) for the pipeline which carries the coral mud to the neutralization system in the nickel plant. An airstrip measuring 3,810 by 100 feet is situated west of the port facility.

## AUXILIARY FACILITIES

The processing systems used at Moa Bay require three other auxiliary facilities in addition to the coral preparation plant described earlier. A plant to generate hydrogen sulphide (Figure 18), a plant to prepare hydrogen (Figure 19), and a plant to produce sulphuric acid (Figure 20) are located in the area of the nickel and cobalt plant.

Hydrogen sulphide for the sulphide precipitation system is generated by direct reaction of hydrogen with sulphur; this reaction is self-supporting and needs no supplemental heat. The hydrogen sulphide, before cooling and liquefaction, is scrubbed with molten sulphur to strip out unreacted sulphur vapor. The hydrogen needed for the process is prepared by reforming liquified

petroleum gas (propane or butane) with steam. These two plants are within the area of the sulphide precipitation plant (item 2, Figure 7), north of a flare tower where excess gas is burned.

The sulphuric acid plant (item 3, Figure 7) consists of two contact units, each rated at 650 tons per day. The plant operates on a standard grade of dark sulphur and also utilizes the high carbon-content blowdown from the hydrogen sulphide plant. High-pressure steam is generated in the waste heat boilers as a byproduct of the sulphuric acid plant. When the Moa Bay complex is in balanced operation, over 50 percent of the high-pressure steam needed for agitation and heating in the leaching system can be generated in the acid plant.

- 11 -

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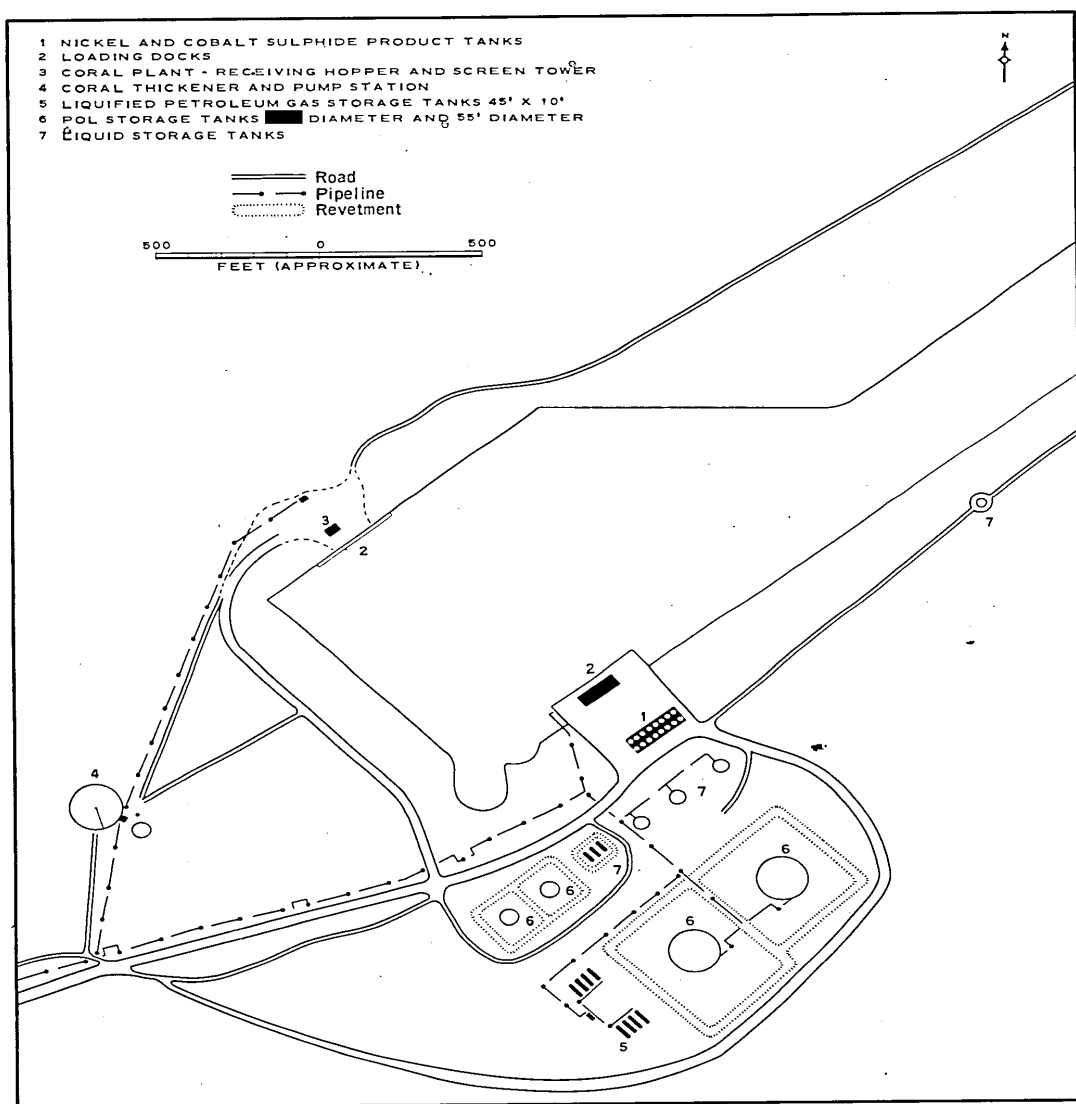


FIGURE 16. PORT FACILITY, MOA BAY NICKEL COMPLEX.

- 12 -

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FIGURE 17. STORAGE TANKS AT PORT FACILITY, MAY 1960.

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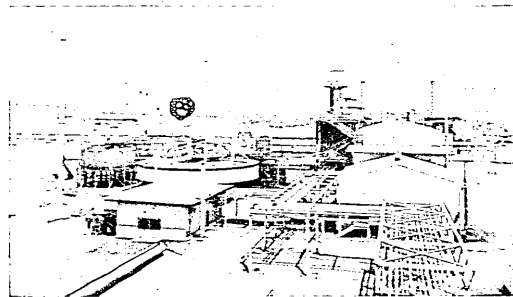


FIGURE 18. VIEW OF HYDROGEN SULPHIDE PLANT FROM THE SOUTH, MAY 1960. Piping rack from the hydrogen plant can be seen in the foreground.

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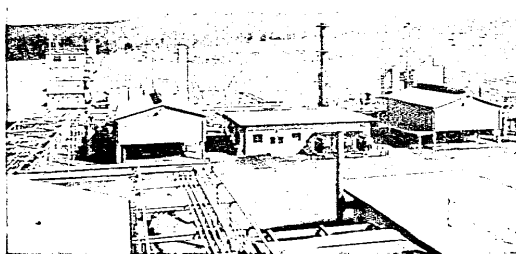


FIGURE 19. VIEW OF HYDROGEN PLANT FROM THE NORTH, MAY 1960.

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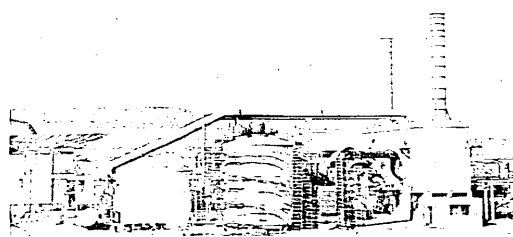


FIGURE 20. VIEW OF SULPHURIC ACID PLANT FROM THE EAST, MAY 1960.

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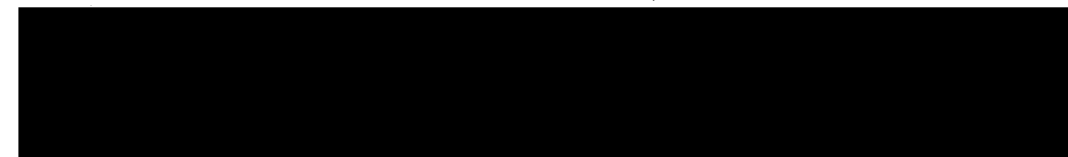
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MAPS OR CHARTS

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